

CONTOUR AND SCOUT SCANNING TECHNIQUE FOR PULSED X-RAY LARGE AREA CT DETECTORS

The present invention relates to the diagnostic imaging arts. It finds particular application in computed tomography, particularly with a pulsed x-ray source and will be described with particular reference thereto. However, the invention will also find application in other imaging devices with a pulsable, rotating radiation source.

5 Computed tomography (CT) imaging typically employs an x-ray source that generates a fan-beam, wedge-beam, or cone-beam of x-rays that traverse an examination region. A subject arranged in the examination region interacts with and absorbs a portion of the traversing x-rays. A one- or two-dimensional radiation detector including an array of detector elements is arranged opposite the x-ray source to detect and measure intensities of
10 the transmitted x-rays.

Typically, the x-ray source and the radiation detector are mounted at opposite sides of a rotating gantry such that the gantry is rotated to obtain an angular range of projection views of the subject. In some configurations, the x-ray source is mounted on the rotating gantry while the radiation detector is mounted on a stationary gantry. In either
15 configuration, the projection views are reconstructed using filtered backprojection or another reconstruction method to produce a three-dimensional image representation of the subject or of a selected portion thereof.

Prior to making a CT scan, a pilot scan is conducted to locate the region of interest, precisely determine scan parameters, and the like. The gantry is fixed against
20 rotation and the patient support is moved axially as the x-ray tube is activated to generate a two dimensional projection or pilot scan. Typically, the x-ray tube is fixed at 12 or 6 o'clock as the subject's couch is driven longitudinally. Other times, the x-ray tube is fixed at 3 or 9 o'clock. Sometimes the x-ray tube operates at reduced energy to reduce radiation dose.

25 There is a continuing demand for CT scanners to rotate at even higher speeds for faster scans. However, it takes a long time or a great amount of energy for the high speed rotating gantry to accelerate to a set velocity and decelerate to a stopping point, making it

undesirable to start and stop for the pilot scans. Larger motors for faster acceleration and braking systems for faster deceleration add cost, complexity and unreliability to the scanner. Moreover, some high speed bearings systems are not conducive to stopping at selected stable positions.

5 The present invention contemplates a new and improved method and apparatus that overcomes the above-reverenced problem and others.

In accordance with one aspect of the present invention, a diagnostic imaging system is disclosed. A means supports a subject. A means translates the supported subject through an examination region. An x-ray source is rotated around the examination region. A means controls pulsing of the x-ray source at a selected angular location around the subject to transmit radiation through the subject as the subject is translated through the examination region. A means detects transmitted radiation, which has passed through the subject. A means reconstructs a pilot scan of the subject from the radiation detected when the x-ray source was pulsed at the selected angular location as the subject was translated through the examination region.

In accordance with another aspect of the present invention, a method is provided for generating a pilot scan. A supported subject is translated through an examination region while an x-ray source is rotated around it. The x-ray source is controlled to pulse at a selected angular location around the subject to transmit radiation through the subject as the subject is translated through the examination region. The radiation, which passed through the subject, is detected by a radiation detector at the selected angular location, as the subject was translated through the examination region.

25 One advantage of the present invention resides in improved accuracy of patient attenuation profiles.

Another advantage of the present invention resides in more accurate pre-scan profiles and safer x-ray dose profiles to the patient.

Yet another advantage of the present invention is that it can generate a constant image quality scan that can take into account not only patient absorption, but also that of the couch.

30 Yet another advantage of the present invention resides in reduced cost.

Still further advantages and benefits of the present invention will become apparent to those of ordinary skill in the art upon reading and understanding the following detailed description of the preferred embodiments.

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The invention may take form in various components and arrangements of components, and in various steps and arrangements of steps. The drawings are only for purposes of illustrating the preferred embodiments and are not be construed as limiting the invention.

10 FIGURE 1 shows an exemplary diagnostic imaging apparatus employing.

FIGURE 2 schematically shows an x-ray source pulsed at 12 o'clock and 6 o'clock as the x-ray source rotates and a subject is linearly translated through an examination region.

15 FIGURE 3 schematically shows the x-ray source pulsed at several angular locations as the x-ray source rotates and the subject is linearly translated through the examination region.

FIGURE 4 shows a diagram of the system.

FIGURE 5 illustrates a preferred method for generating a pilot scan.

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With reference to FIGURE 1, a computed tomography (CT) imaging apparatus or scanner 10 includes a stationery gantry 12 that supports a rotating gantry 14. An x-ray source such as x-ray tube 16 and a source collimator 18 cooperate to produce a fan-shaped, cone-shaped, wedge-shaped, or otherwise-shaped x-ray beam directed across 25 an examination region 20 to an array of x-ray detectors 22. Preferably, the x-ray detectors 22 are mounted on the rotating gantry, but may, optionally, be mounted on the stationary gantry surrounding the rotating gantry. A resolver 24 determines an angular orientation of the rotating gantry as it is rotated, preferably at high speed, e.g. 200rpm, by a motor 26 on high speed mechanical bearings, air bearings, magnetic bearings, or the like.

30 A subject support or patient couch 30 is driven by a motor 32 to move longitudinally along Z-axis into and through the examination region 20. A encoder 34 monitors movement of a substantially, but not completely, radiotranslucent patent

supporting surface 36 of the subject support 30 and provides an electrical output signal indicative of its axial position.

An operator uses a graphical user interface or other user interface means 40 to provide pilot scan parameters, imaging scan parameters, and other parameters to a system controller 42. The system controller controls the motor 26 to control the speed at which the rotating gantry 14 rotates, controls the motor 32 of the patient couch to control advancement and position of the subject. More specifically, the system controller 42 includes a pilot scan controller 44 which controls the gantry and couch motors and the x-ray tube during pilot scans and a 3D image controller 46 which controls these motors and the x-ray tube during volumetric diagnostic imaging scans. Preferably, a scan memory 48 is preloaded with a selection of selectable pilot and imaging scan sequences.

Data from the detector 22 generated during a pilot or volumetric scan is conveyed to a buffer memory 50. The data along with angular gantry position from the resolver 24 and patient couch position from the encoder 34 are supplied to an image processor 52, either directly or through the buffer memory 50. The image processor 52 conveys buffer scan data to a pilot scan processor 54, which generates one or more two-dimensional pilot scan images. During a diagnostic volumetric scan, the image processor 52 conveys the data, angle, and position information to a 3D image processing system 56. Data from the pilot or 3D image processing systems are placed in appropriate form for display by a video processor 58 and conveyed to a display terminal of the user interface 40.

A dose calculation processor 60 analyzes the pilot scan or a region of the pilot scan designated on the user interface to determine recommended scan parameters for the diagnostic imaging scan. The recommended parameters are conveyed to the system controller 42 and are displayed on the user interface 40 so that the operator can review and adjust the recommended scan parameters.

With reference to FIGURE 2, in one embodiment, the pilot scan controller pulses the x-ray tube 16 each time the x-ray tube 16 reaches fixed angles, such as 6 o'clock and 12 o'clock. The pilot scan controller further controls the couch motor 32 such that in each half revolution, the couch 30 advances by the irradiated cross-section. Optionally, the 12 o'clock and 6 o'clock scans can overlap, in which case the pilot image processor 54 averages or otherwise blends the overlapping data.

In another embodiment, the x-ray tube 16 is pulsed at only 12 o'clock (or 6 o'clock) and the subject couch 30 is advanced at half the speed.

In another embodiment, the x-ray tube 16 is pulsed at 3 o'clock and 9 o'clock to generate a vertical projection pilot image and a horizontal projection pilot 5 image simultaneously.

With reference to FIGURE 3, in another embodiment, the x-ray tube 16 is pulsed at numerous positions around the patient. Additional pilot images at various angles can be generated. Preferably, the data generated by pulsing the x-ray tube 16 at the additional angles is used to determine the contour of the patient. When the x-ray tube 16 10 pulsed solely for gaining patient contour information, the x-ray tube 16 can be pulsed at a lower energy to expose the patient to less dosage. When determining the contour, the detected data need only have sufficient gray scale resolution to distinguish between the presence and absence of a subject, and need not discriminate among the various tissues within the patient. The patient contour combined with the projection pilot scans is used by 15 the dose calculation processor 60 to determine patient density as a part of determining the appropriate dose. From the determined dose, a scan parameter calculator 62 determines suggested scan parameters, which are loaded into the scan memory 48 and displayed to the operator on the user interface 40 for review and modification.

With reference to FIGURE 4, an exemplary pilot scan control 44 includes a 20 comparing means 70 for comparing the instantaneous gantry angle with a selected gantry angle from a buffer memory 72, which stores the angles at which the x-ray tube is to be pulsed, as described in conjunction with FIGURES 2 and 3. The buffer memory 72 is loaded either directly from the user interface 40 or from a scan memory 48, which stores a plurality of preselected pilot and imaging scan parameters. Each time the rotating gantry 25 14 is sensed to reach one of the selected angles, the comparing means 70 causes an x-ray tube pulsing means 74 to cause an x-ray tube control circuit 76 to pulse the x-ray tube 16. A gantry speed control 78 and a couch speed control 80 are controlled either directly from the user interface 40 or with preloaded pilot scan parameters from memory 48 to coordinate the couch advancement with the rotational speeds as discussed above in 30 conjunction with FIGURE 2.

A pilot scan reconstruction processor 90 assembles each of the projection pilot scans into a projection image, which is stored in a pilot image memory 92. The video

processor 58 selectively withdraws pilot scans from the memory 92 and displays them on the user interface 40. The pilot reconstruction processor 90 also reconstructs the contour of the subject as described above and loads the contour images into the pilot image memory 92. From the contour images and the gray scale, hence density of the projection 5 pilot images, the dose calculation processor 60 calculates recommended imaging scan parameters. These imaging scan parameters are provided to the scan memory 48, which loads the scan parameters into the imaging scan control 46. Preferably, the parameters are also displayed to the operator on the interface 40 to permit the operator to make parameter adjustments, designate a limited region of interest, and the like. An x-ray tube controller 10 94 causes the x-ray tube control 76 to control the x-ray tube 16 with the selected intensity parameters. A gantry speed controller 78' controls the gantry speed and a couch speed controller 80' controls the couch speed in accordance with the selected imaging scan parameters.

The diagnostic image data from the buffer memory 50 is supplied to the 3D 15 image processor 56. A 3D reconstruction processor 100 reconstructs the diagnostic data into one or more three-dimensional volumetric image representations that are stored in volumetric image memory 102. The video processor 58 withdraws selected portions of the three-dimensional image representations for display on the user interface 40.

Typically, the subject has a non-uniform cross section. Thinner or more 20 penetrable parts of the subject require less radiation for producing the desired image quality. Thicker or less penetrable parts of the subject require more radiation to produce a desired image quality. It is desirable to minimize the radiation dose during CT scan while maintaining a good image quality. In the preferred embodiment, the scan data is collected at a plurality of angular locations. The dose processor 60 determines the optimal radiation 25 dose, based on the pilot scan attenuation data. This will allow planning a low radiation dose, while maintaining a "constant image quality" throughout the scan or series of scans of the subject with the non-uniform cross section.

With reference to FIGURE 5, after the pilot scan is completed 110, the set of data is obtained that has a relationship between the subject's geometry and the translation of 30 the subject support 30. The attenuation data, indicative of the radiation absorption characteristics of the subject, is obtained 112 and analyzed to produce the optimal radiation dose 114. The operator selects a scan mode of operation and sets the parameters for the

scan. The scan is conducted utilizing the pilot scan data and administering the minimum radiation dose determined to produce a constant image quality 116.

The invention has been described with reference to the preferred embodiments. Modifications and alterations will occur to others upon a reading and
5 understanding of the preceding detailed description. It is intended that the invention be construed as including all such modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof.